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# **Terminal Weather System with Fast-Scanning Phased Array Weather Radar in Japan**

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## 1. Background

- ◆ “Strategic support” and “Tactical support”
- ◆ Weather scales and observation

## 2. Weather and Airport Operation

- ◆ Aviation weather issues
- ◆ Demands in Japan

## 3. Researches for Terminal Weather System

- ◆ Practical needs
- ◆ Technological seeds
- ◆ Phased Array Weather Radar (PAWR)
- ◆ JAXA's challenges

## 4. Summary

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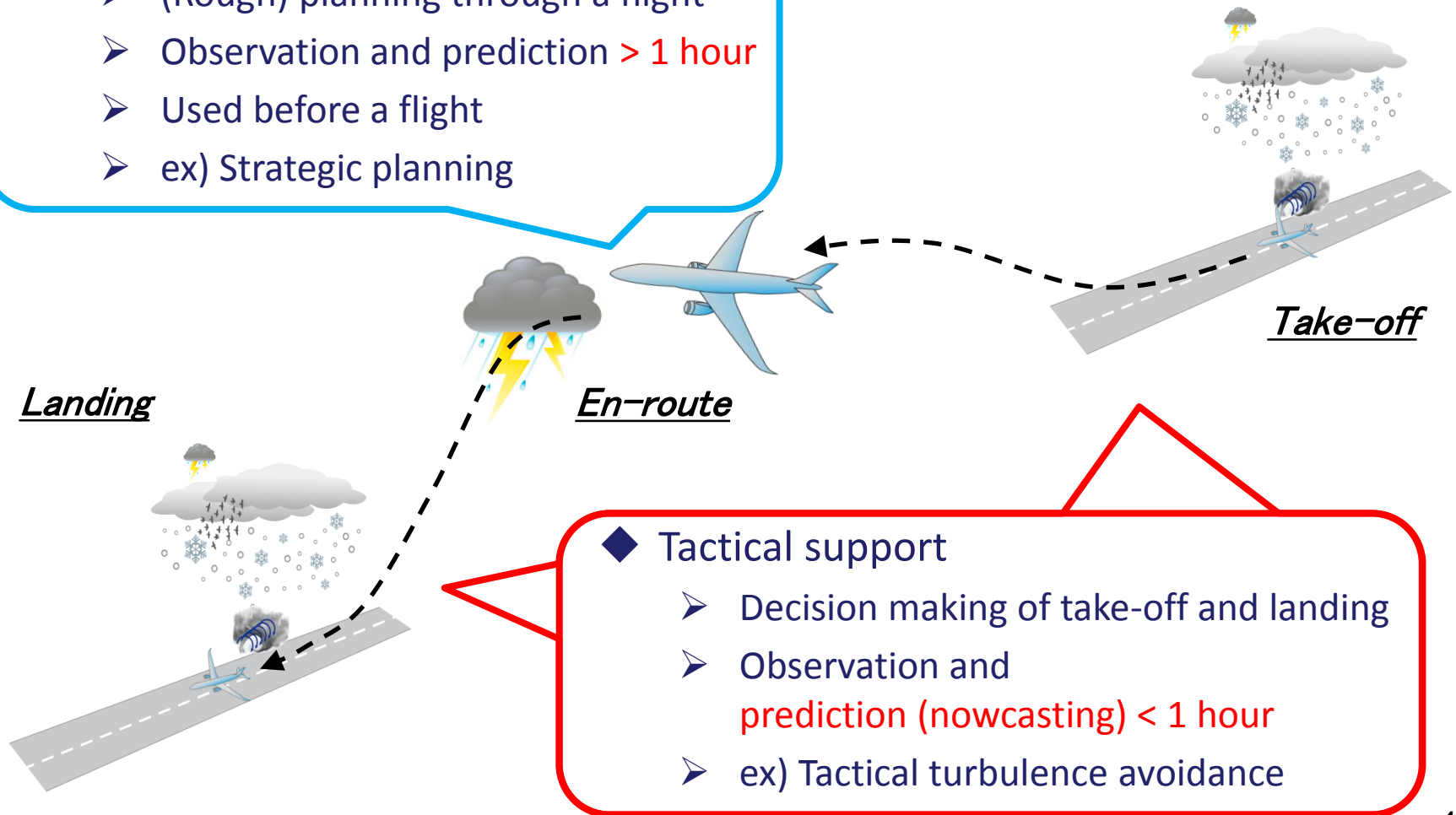
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# “Strategic support” and “Tactical support”

## ◆ Strategic support

- (Rough) planning through a flight
- Observation and prediction > 1 hour
- Used before a flight
- ex) Strategic planning

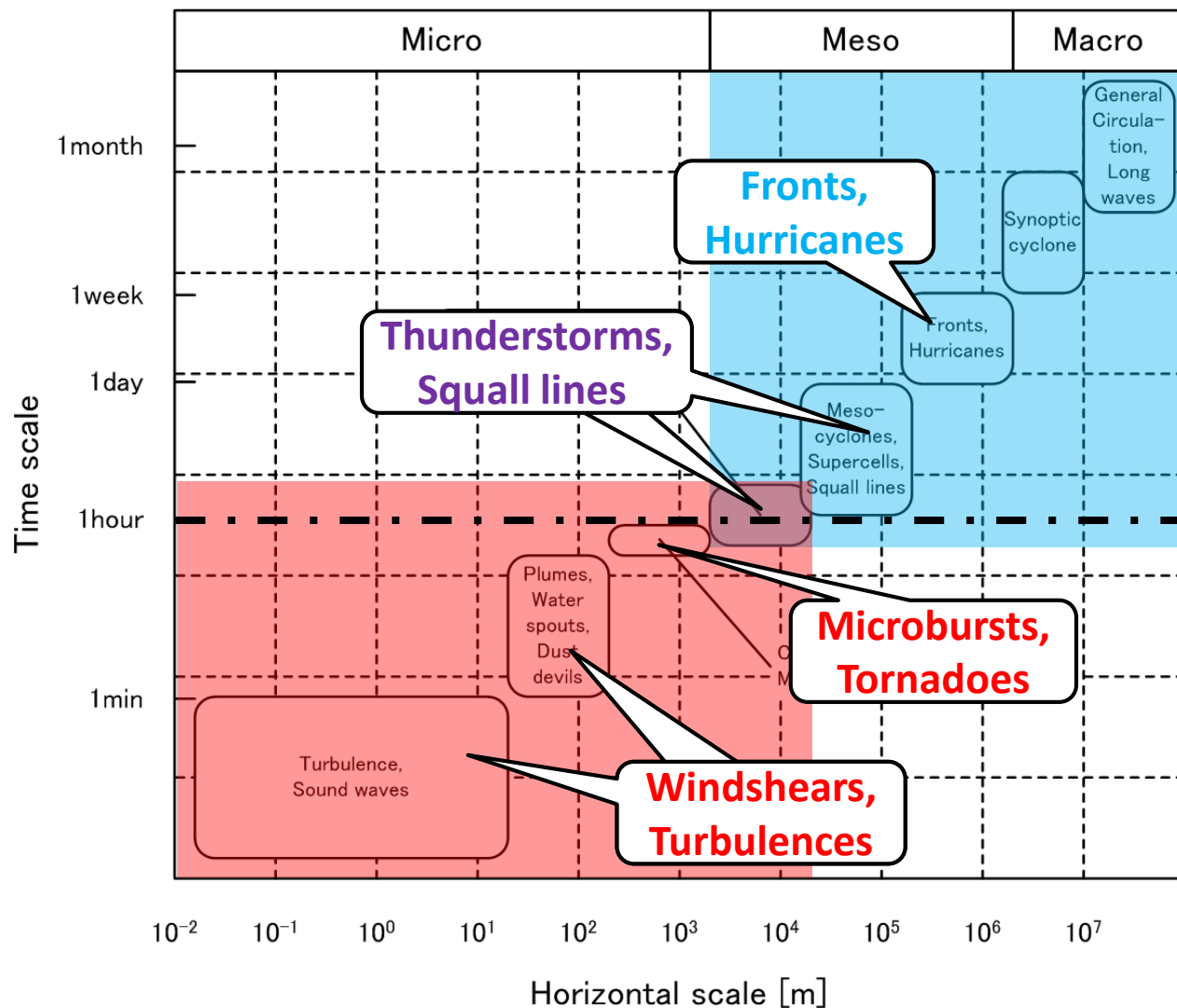


## ◆ Tactical support

- Decision making of take-off and landing
- Observation and prediction (nowcasting) < 1 hour
- ex) Tactical turbulence avoidance

# Weather scales and observation

## ◆ Space-time plot of weather phenomena



- Spatial scale
- ∞ Temporal scale
- Using conventional observation devices, ...
  - ✓ Fronts, Hurricanes; Strategic support
  - ✓ Microbursts; Tactical support

Strategic

Tactical

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- ◆ Low visibility
  - Less than airport weather minimums of ceiling and visibility  
⇒ Delay by holding or diversion to an alternate airport
- ◆ Wind
  - Airport scale (meso-scale) wind  
⇒ Groundstop by strong wind or delay by runway change
  - Low-level wind shear and turbulence (micro-scale)  
⇒ Accident, incident, delay by go-around, or divert to an alternate airport
- ◆ Icing cloud
  - Stall due to aircraft icing ⇒ Accident or incident
  - Avoidance of icing cloud ⇒ Delay by holding
- ◆ Lightning cloud
  - Lightning (or hail) strike to an aircraft  
⇒ Cost and delay to repair, or flight cancellation
  - Avoidance of lightning cloud ⇒ Delay by holding
- ◆ Accumulated snow
  - Poor runway condition by snow, etc. ⇒ Overrun or go-around

# Demands in Japan

## Lightning

- ◆ Hundreds of aircrafts have been damaged per year.
- ◆ “**Winter lightning**” is especially problematic due to its **high energy**.



## Windshear and turbulence

- ◆ Windshear and turbulence are hazardous especially in a low level.
- ◆ **Complex combination of geometrical and convective causes**



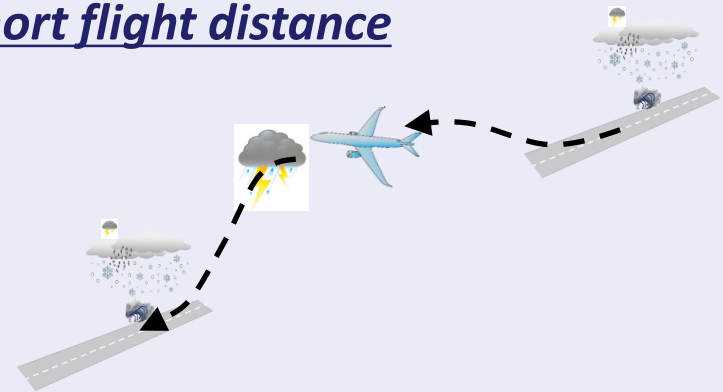
## Icing condition

- ◆ **Icing runway** is problematic **in north side** of Japan.
- ◆ Flight cancel: Hundreds of flights
- ◆ Divert: Tens of flights
- ◆ Overrun or stuck: One or two



## Short flight distance

- ◆ **Short flight distances in domestic flights**



All these Japanese characteristic issues demand  
**a more sophisticated tactical support.**



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# Practical needs

◆ Low visibility ⇒ Capacity

- Improvement of prediction for ceiling and visibility

◆ Wind ⇒ Safety and Capacity

**Second priority**

- Improvement of prediction for airport scale (meso-scale) wind
  - ✓ Wind speed in case of strong wind such as typhoon
  - ✓ Wind direction in normal cases
- Development of prediction of low-level wind shear and turbulence

◆ Icing cloud ⇒ Safety and capacity

- Development of detection and prediction for icing cloud

◆ Lightning cloud ⇒ Safety, capacity, and cost

- Improvement of detection and prediction for lightning cloud
- Improvement of weather phenomenon classification, such as microburst, tornado, and so on.

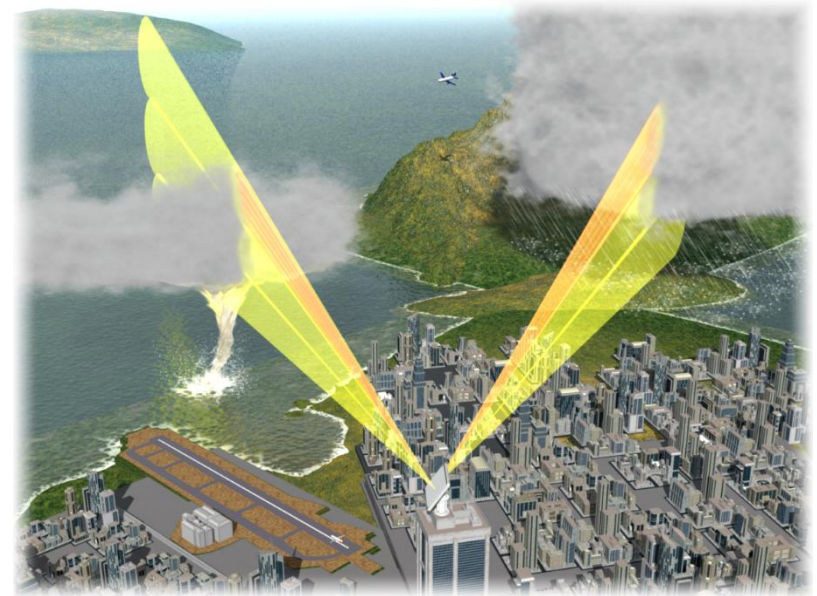
**First priority**

◆ Accumulated snow ⇒ Safety and capacity

- Development of runway condition classification
- Development of calculation method for runway frictional coefficient

# Technological seeds

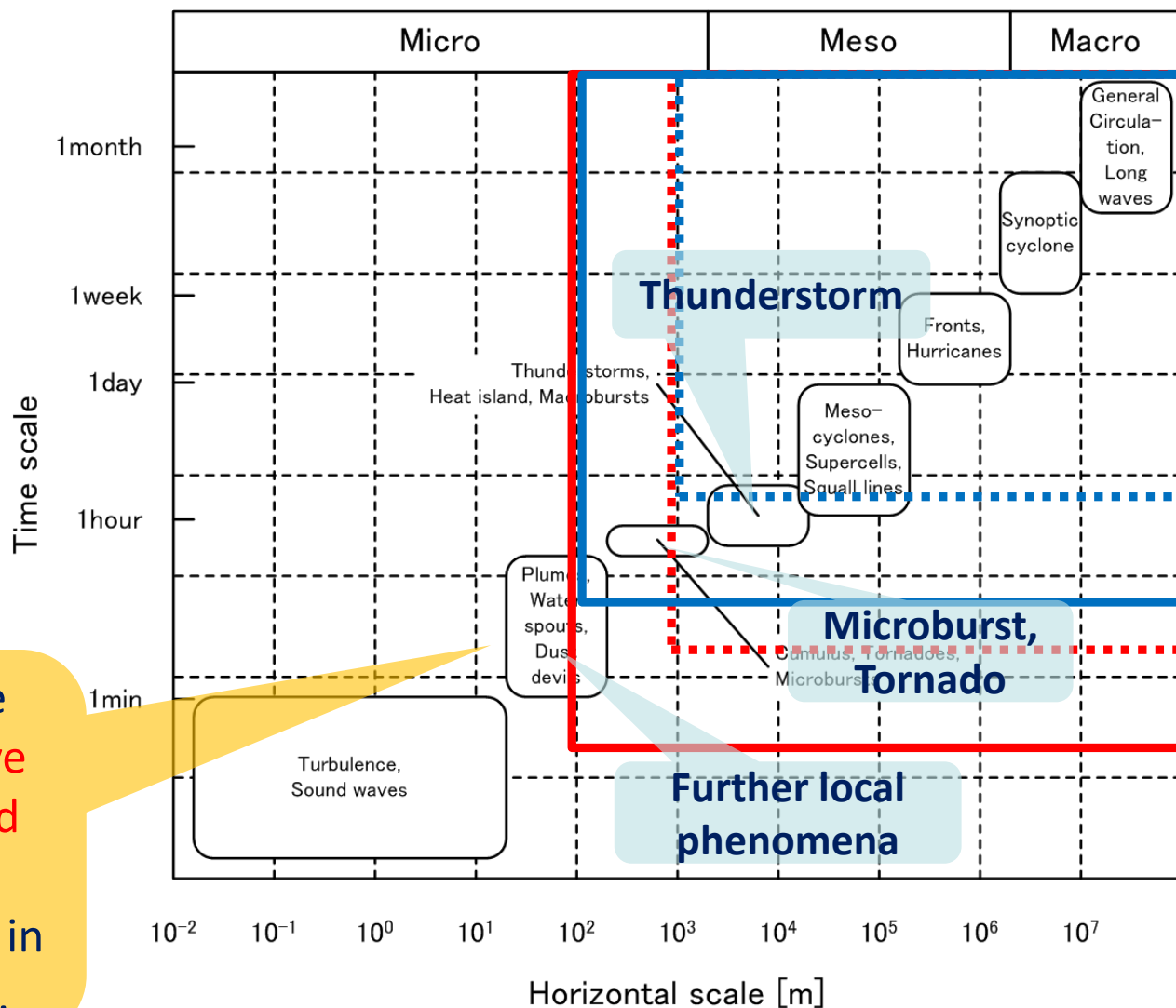
- ◆ **Phased Array Weather Radar (PAWR)**,  
by Osaka univ., Toshiba Corp., and NICT.
  - The first operational PAWR applying digital beam forming technology to achieve superb fast-scanning capability.
  - Measures precipitation (Intensity and velocity).
  - **Fast-scanning ( $\leq$  ASR)**
  - **High accuracy ( $\approx$  NEXRAD).**



- ◆ Broadband Observation network for Lightning and Thunderstorm (BOLT)
  - Measures high-quality electrical structure inside a cloud
- ◆ Aircraft sounding and fast data downlink technology
  - SSR mode S delivers **in-situ measured data (wind and temperature) in real-time.**
  - A number of measurements are available in hub-airport areas.
- ◆ Cloud radar (Ka-band dual-polarization radar)
- ◆ Wind lidar

# Phased Array Weather Radar

Spatial – Temporal Scale of Weather Phenomena



Prediction range  
Conventional radar

Detection range  
Conventional radar

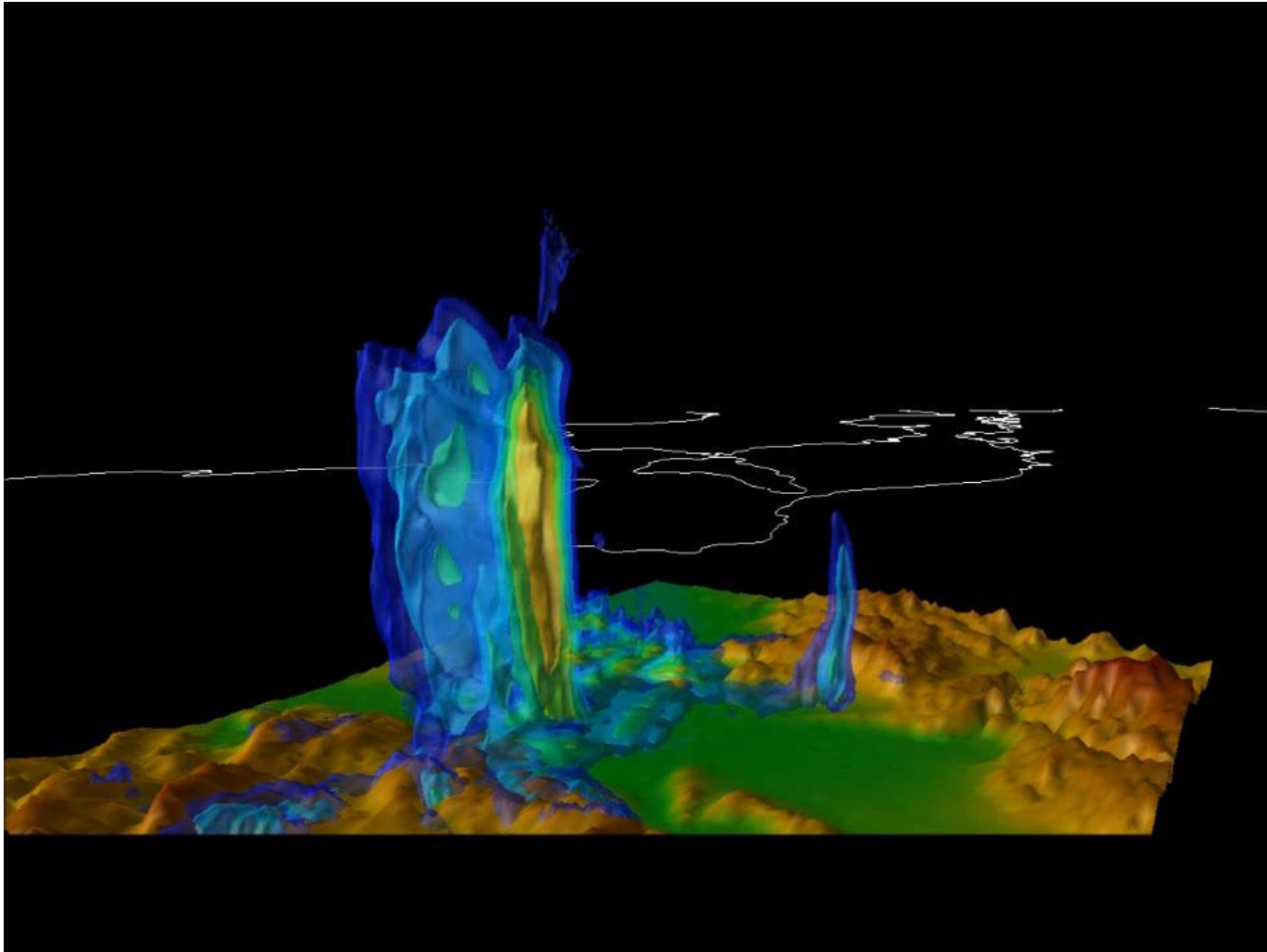
Prediction range  
Novel radar

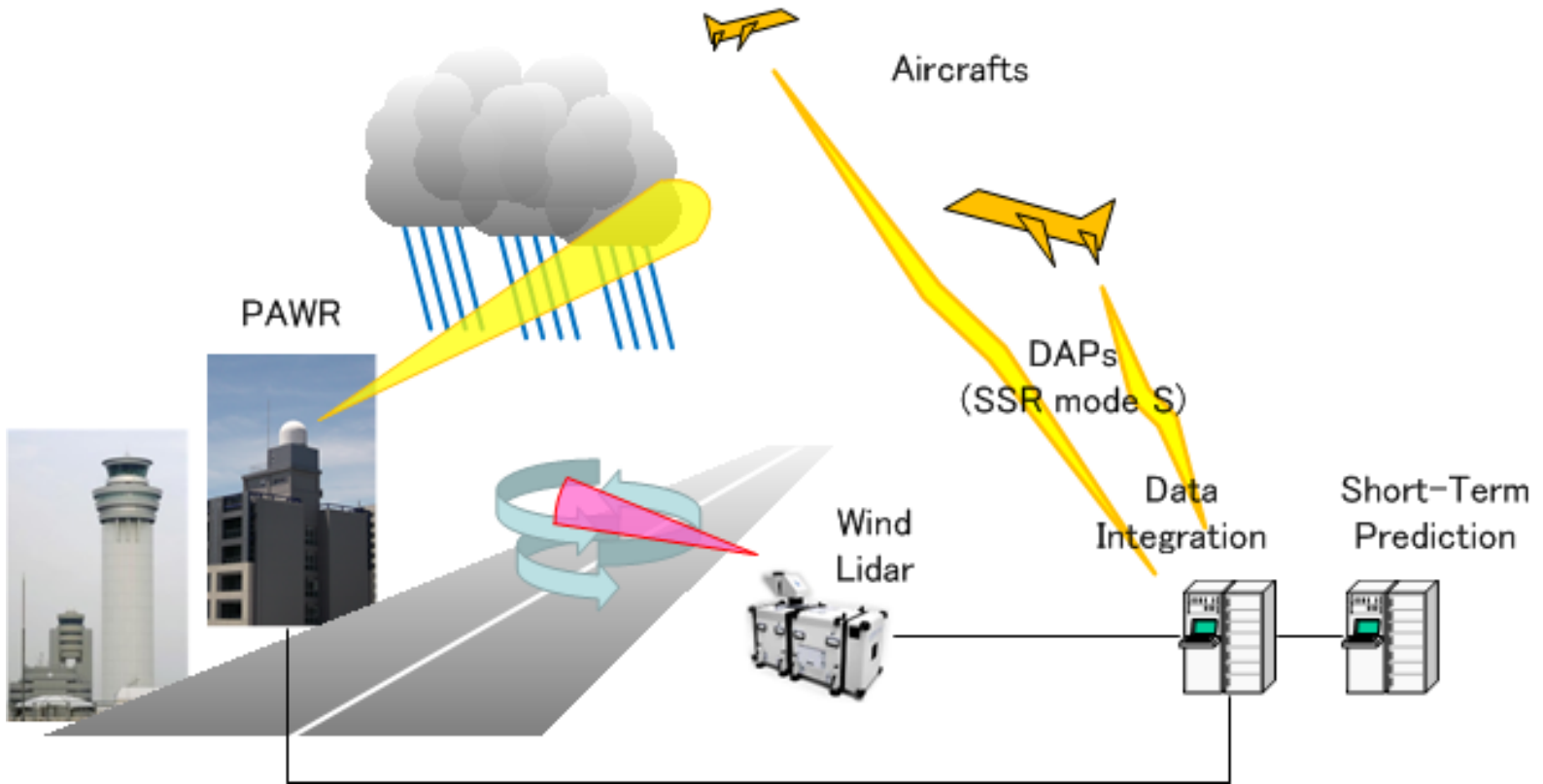
Detection range  
Novel radar

Novel radars have potential to achieve both detection and prediction of hazardous weather in aircraft operation.

# Phased Array Weather Radar

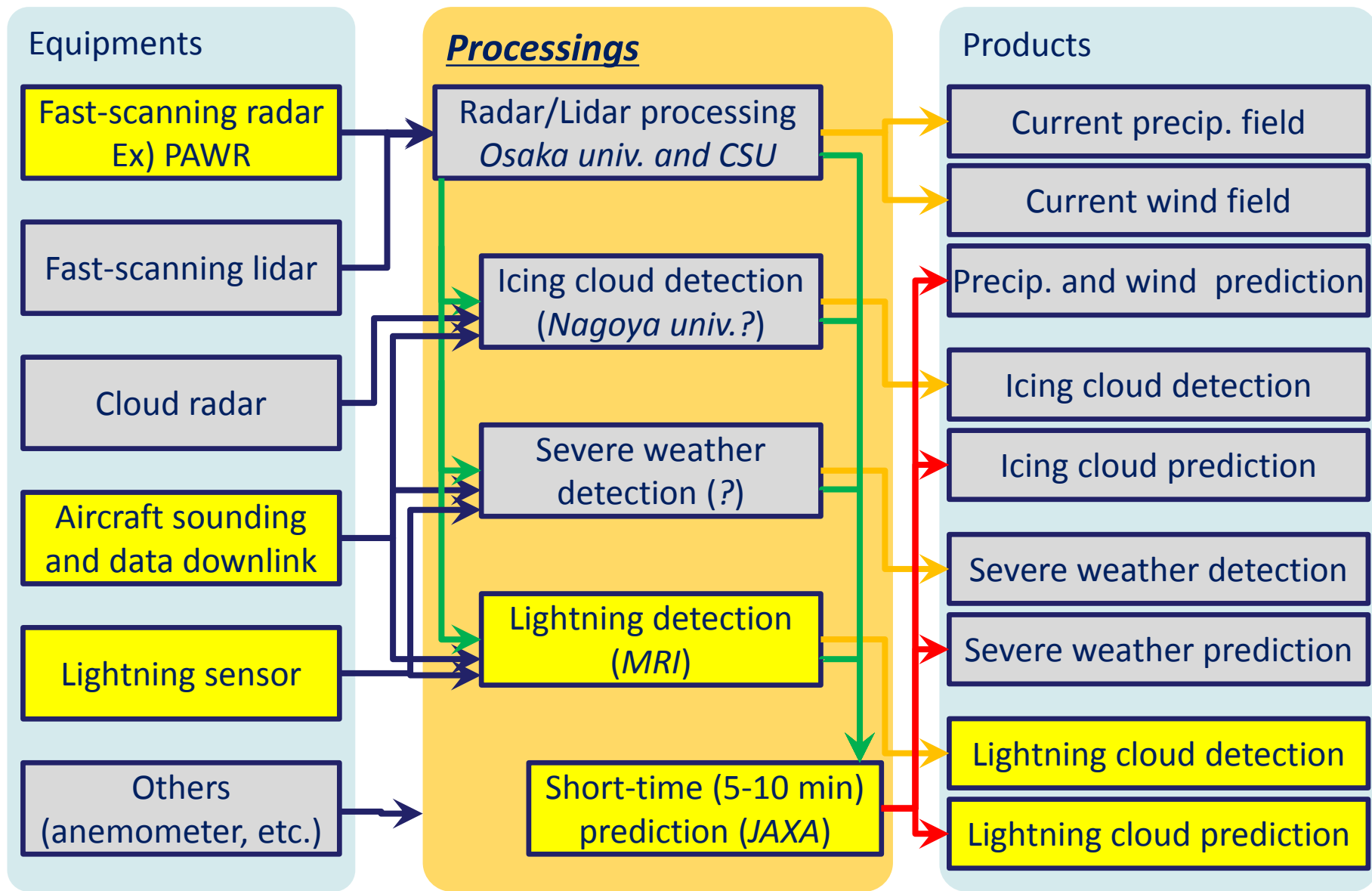
## ◆ Demo movie





- ◆ JAXA's challenge is to develop **a terminal weather system with a more sophisticated tactical support** than conventional ones.
- ◆ Specifically, it is **a connection between the practical demands and the technological seeds**.

# JAXA's challenge



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## ◆ Conventional aviation weather support

- Strategic supports (> 1h) has been accomplished by conventional observation devices. Many of great products have been released.
- Tactical support (< 1h) is basically beyond capability of conventional observation devices. Less number of products, such as microburst alert, have been utilized.

## ◆ Practical needs and technological seeds

- Issues due to characteristic weather in Japan and Japanese ATM environment demand a more sophisticated tactical support.
- Novel observation devices such as PAWR have achieved high resolution which has a big potential to respond the demands.

## ◆ JAXA's challenge

- **Development of a new tactical support system mainly for lightning, icing, windshear, and turbulences based on novel observation devices.**

## ◆ **Welcome to invite you all!** (because we just started this research last year...)

- Very welcome to make **collaborations in both organization and personal levels**; project reseachers (postdoc), permanent researcher, and so on.
- If interested, **please contact me via IFAR Link.** (Also email is OK.)

# Summary

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Thank you for attention!

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